Nonlinear Dynamics Workshop

ESRF, Grenoble, France
26 – 28 May 2008

Kai Hock

Liverpool Group Meeting, 18 April 2008

Overview

- Goals and participants
- Excerpts of talks
- Summary by R. Bartolini
- Some photos

Goals

- Nonlinear models of beam dynamics
- Comparison with experiments:
  - Lifetimes
  - Dynamic apertures
  - Frequency maps

- The motivation is to improve light source performance.

All presentations slides are available from the workshop website:

ttp://www.esrf.eu/Accelerators/Conferences/non-linear-beam-dynamics-worksho

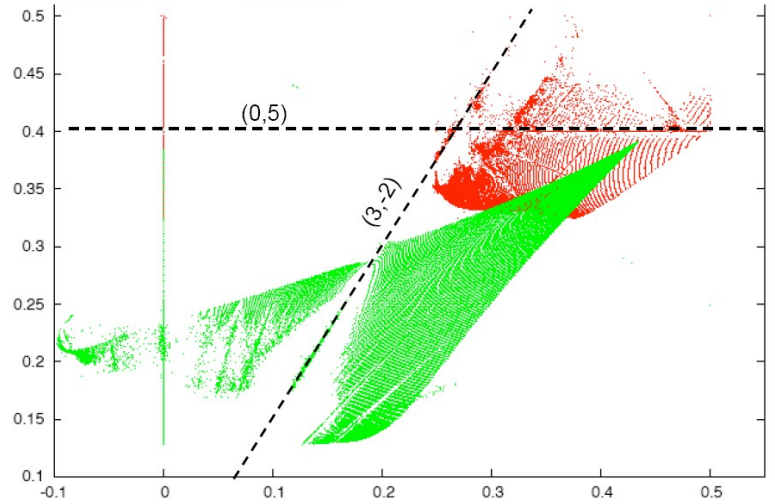
The participants come from these organisations:

Diamond, UK	SOLEIL, France
ELETTRA, Italy	ALBA-CELLS, Spain
CELLS	ANKA, Germany
ESRF, France	CERN
APS, USA	SPring-8, Japan
BNL, USA	Australian Synchrotron
Cockcroft, UK	M.A.X.-Lab, Sweden
SLAC, USA	SSRF, China
DESY, Germany	BESSY, Germany

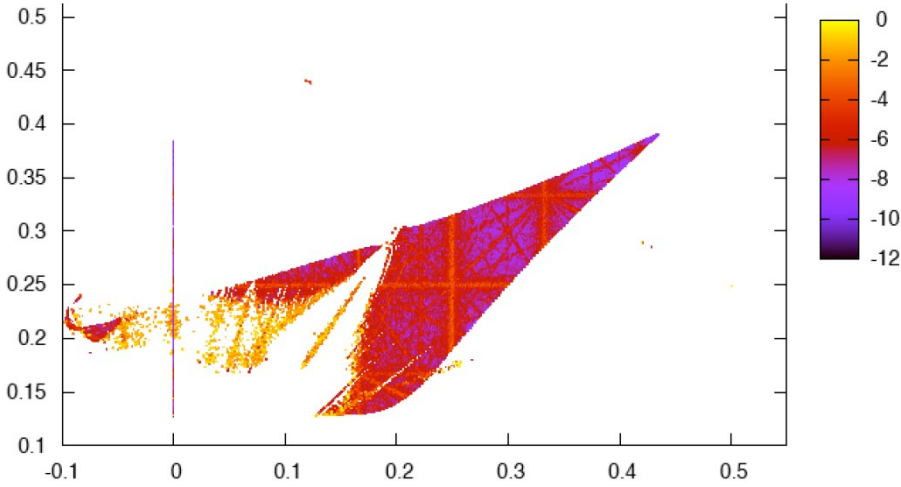
Frequency maps from symplectic integrators

- **Yannis Papaphilippou, CERN**
  - Consider the old ESRF “ideal” lattice, i.e. perfectly symmetric (periodicity of 16) with the only non-linearity coming from the sextupoles

■ Comparison between frequency maps produced by “drift-kick” 1 kick versus 10 kicks

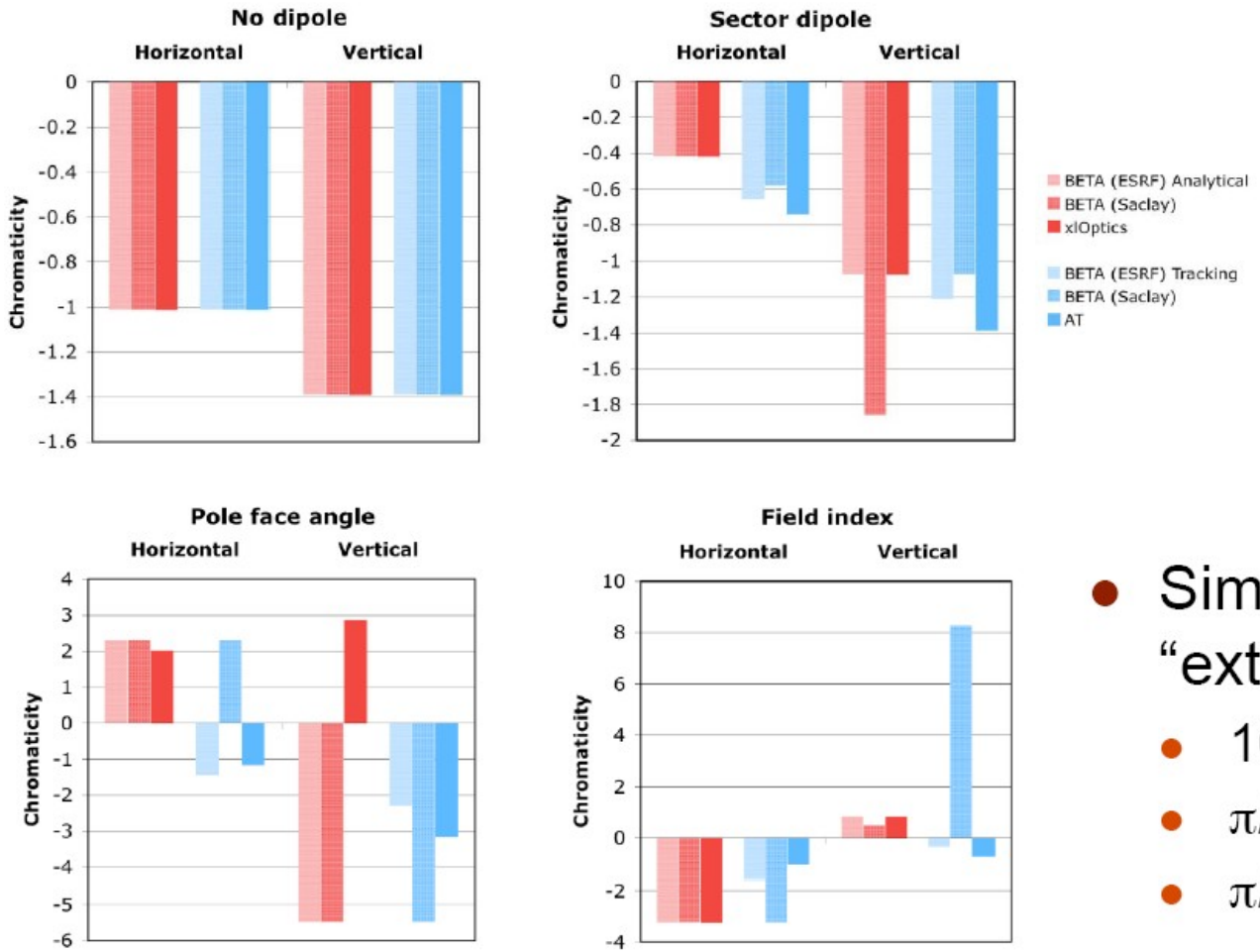


■ Frequency map using the $SABA_2C$ symplectic integrator reproduces the “10-kick” case



Comparing results of different codes

- Laurent Farvacque, ESRF
  - Disagreement increases as parameters become more extreme

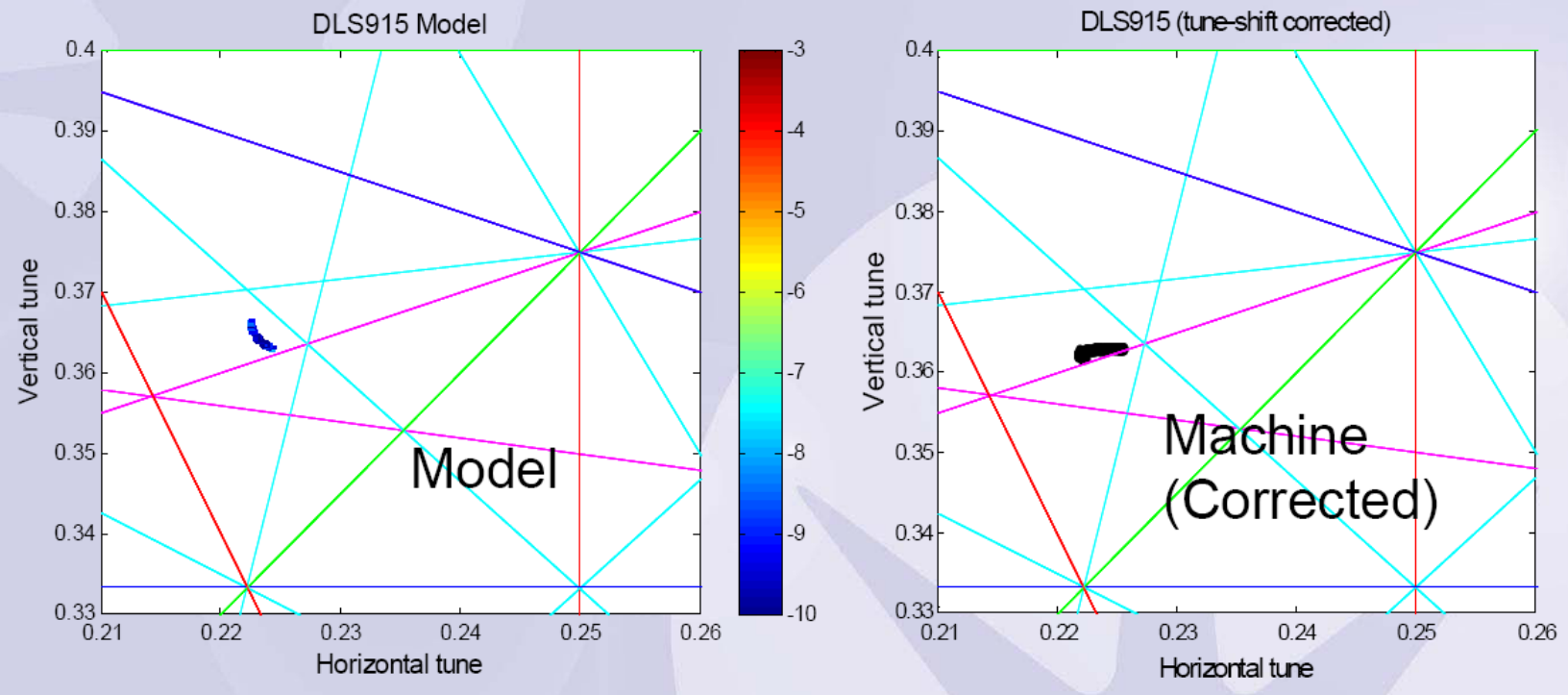


- Simulation in "extreme" conditions:
  - 10 m dipole radius
  - $\pi/2$ bending angle
  - $\pi/4$ pole face angle

Frequency Map in Diamond

Ian Martin, Diamond

Comparing simulation with experiment



Search for “Bad” Sextupole

Louis Emery, APS

Beam lifetime suddenly was reduced by 20%-30% after a shutdown

Assuming the cause was a bad sextupole magnet, what beam based tools do we have?

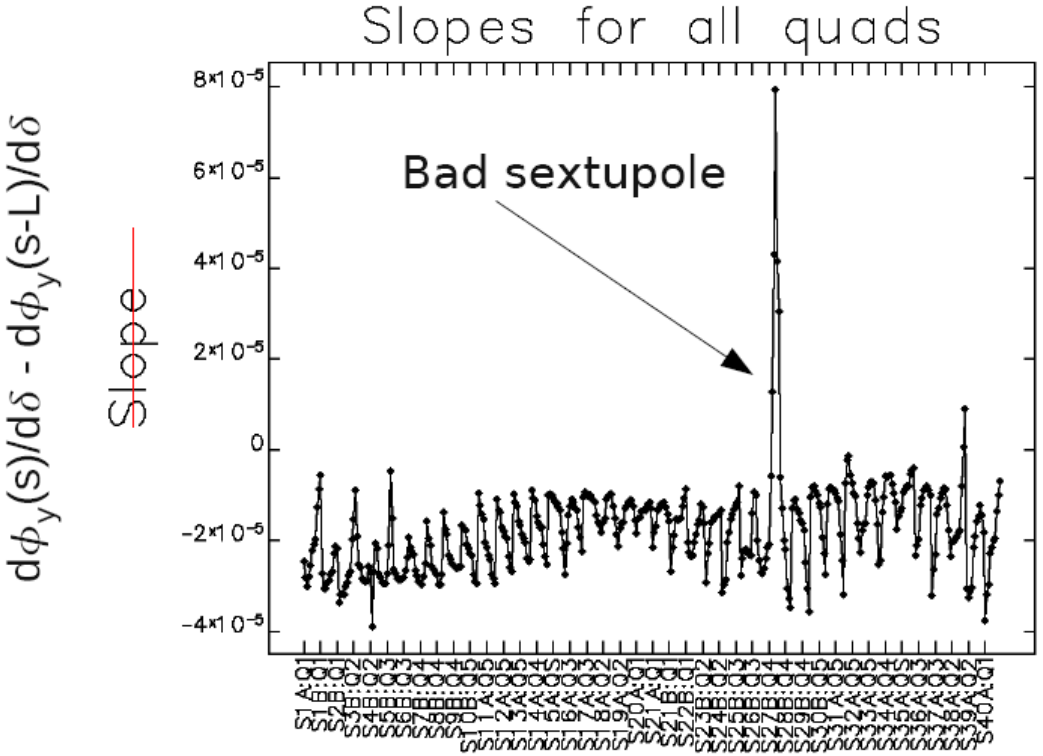
– Tune: tunes dependence on orbits through sextupoles

– Orbit: Response matrix measurements at different momentum

– Chromaticity: various sectors of sextupoles turned off

...

Local Chromaticity Measurement



Summary by Riccardo Bartolini, Diamond

The comparison of the nonlinear optics is still far from the accuracy achieved for the linear optics. Firstly, a discrepancy in the behaviour of the various codes

AT
BETA-ESRF
BETA-SOLEIL
Elegant
MAD-PTC
MAD-X
TRACY-II SLS
TRACY-II SOLEIL
TRACY-III

was highlighted. It was pointed out that different answers are likely to be the consequences of different assumptions used in the codes and that should be adequately considered.

Summary by Riccardo Bartolini, Diamond

Secondly, it was suggested that a “road-map” should be followed to qualify the comparison machine to nonlinear model, indicating the physical quantities characterising the nonlinear optics. The physical quantities discussed during the workshop were

Nonlinear dispersion
Detuning with momentum
Detuning with amplitude
Apertures (on and off momentum)
Lifetime
Frequency Maps (x –z and x –dp/p)
Resonance driving terms
Chromatic phase advance

Each facility presented the results of the measurements performed to characterise the nonlinear beam dynamics.

Chromaticity – one of the results (Laurent Nadolski)

SOLEIL reported a very good agreement on a lattice with chromaticities +3 in both planes up to a dp/p of ±3.5%,. The measured values are limited at positive off momentum by an integer resonance and at negative off-momentum by loss on the longitudinal dynamics.

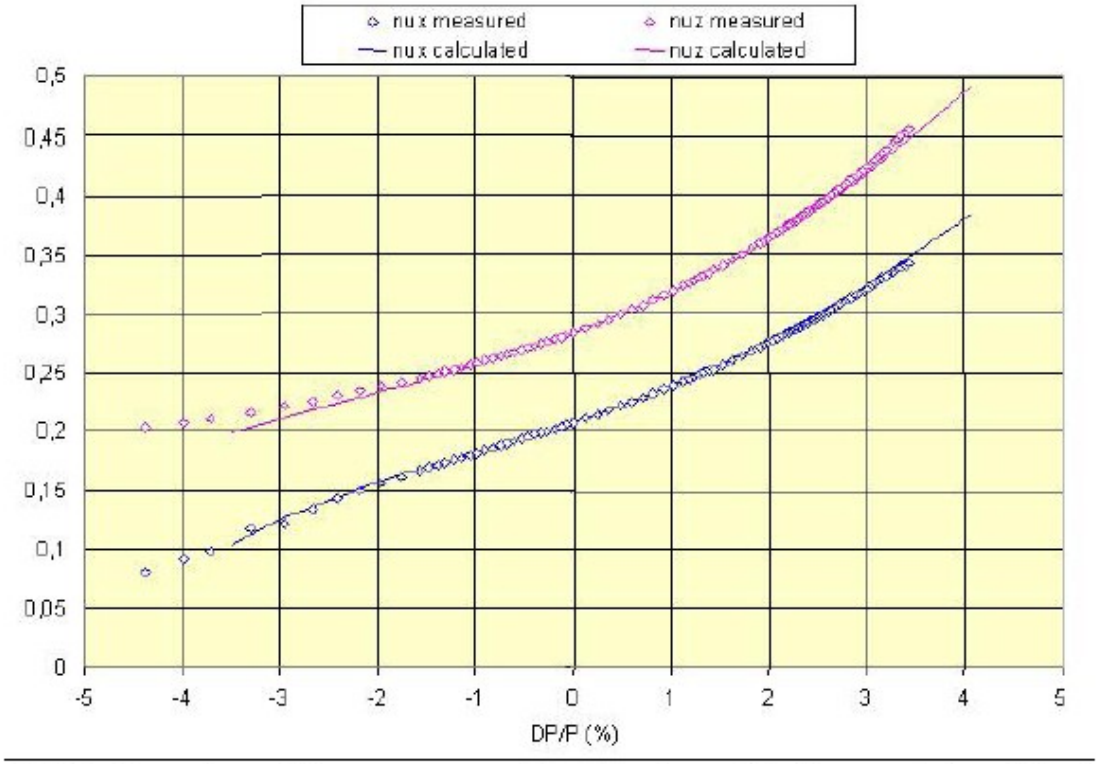


Fig. 2.4: SOLEIL detuning with momentum for a lattice with chromaticity +3 in both planes.

Summary by R. Bartolini, Diamond

Momentum aperture

Review of momentum apertures

Momentum apertures are measured with scans of lifetime vs RF cavity voltage or with Tosuchek lifetime measurments. Momentum apertures are generally smaller than predicted by the numerical simulations. Tab. 1 summarises the results reported at the workshop. One can conclude that the agreement is reasonable although not excellent. The SLS appears to be the farthest form the predicted momentum aperture..

Machine	Measured aperture	Model Aperture
BESSY-II	2.5%	± 3% (RF)
Diamond	3.5%	- 5% to 3.5% (RF + α_2)
ESRF	2.4%	± 2.5% (RF)
SLS	1.8%	± 3% (RF)
SOLEIL	- 4.6% to 3.5%	- 6% to 3.8% (RF + α_2)
SPEAR3	± 3% (RF)	± 3% (RF)

Tab. 1: Summary of momentum apertures measurements

Summary by R. Bartolini, Diamond

Dynamic Aperture – one of the results (Ian Martin)

At Diamond the aperture were measured both with a scraper and with kicking the beam to large amplitude with the pinger magnets. Both apertures are lower than predicted by the model and this discrepancy is under investigation and is likely to be due to a dynamic aperture problem. Scraper and pinger data agree in the horizontal plane (about 11 mm) while the kicked beam give a significantly lower vertical aperture (2.7 mm) than the scraper (about 5 mm). N.B the scraper data were not shown at the workshop.

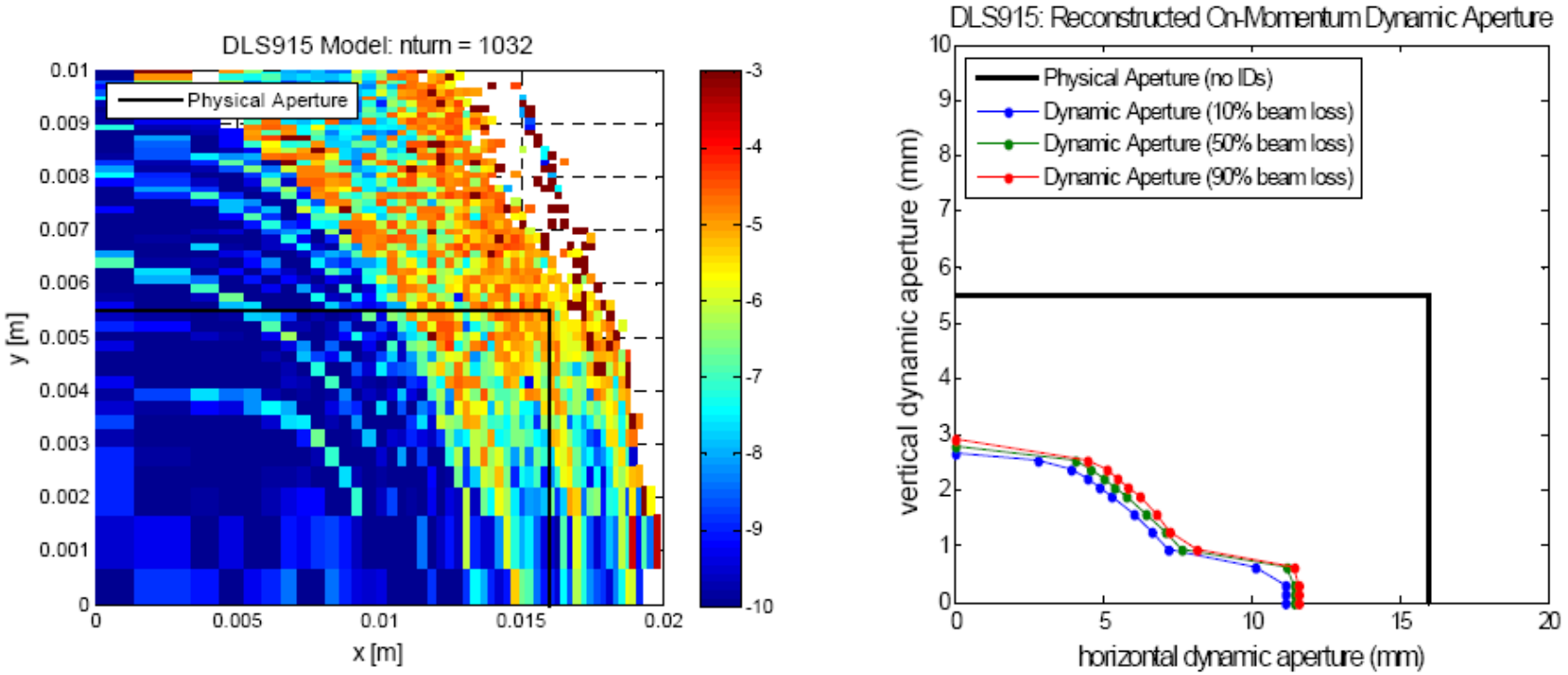


Fig. 2.11: Diamond DA (left) and measured on momentum aperture in both planes (right)

Summary by R. Bartolini, Diamond

Touschek Lifetime

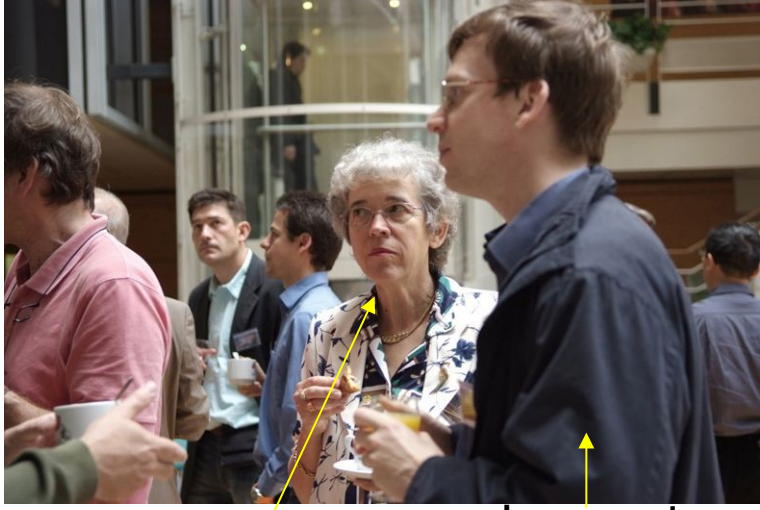
Review of Touschek lifetime

Lifetime is limited by apertures (dynamic or physical depending on the machine)

Machine	Measured lifetime	Model lifetime
BESSY-II (240 mA)	10 h (all)	-
Diamond	16 h (all)	22 h
ESRF (single bunch, low coupling, dp/p = 2.4%)	11 h (all)	16 h
SLS (dp/p 1.8%, chro =0.4, coup 0.4%)	8 h (Touschek)	8 h
SOLEIL (250 mA, 312 bunches, k=0.9%, 2.4 MV; dp/p = -4.6%; 3.5%)	17.3 h (Touschek)	16.4 h
SPEAR3 (100 mA, 280 bunches, k=0.1%, 3.2 MV, dp/p = ±3%)	61.3 h (Tosuchek)	66.3 h

Also:
- Resonance driving term measurement
- Effect of insertion devices

Summary by R. Bartolini, Diamond



Yannis Papaphilippou

Louis Emery

Riccardo Bartolini

Annick Ropert

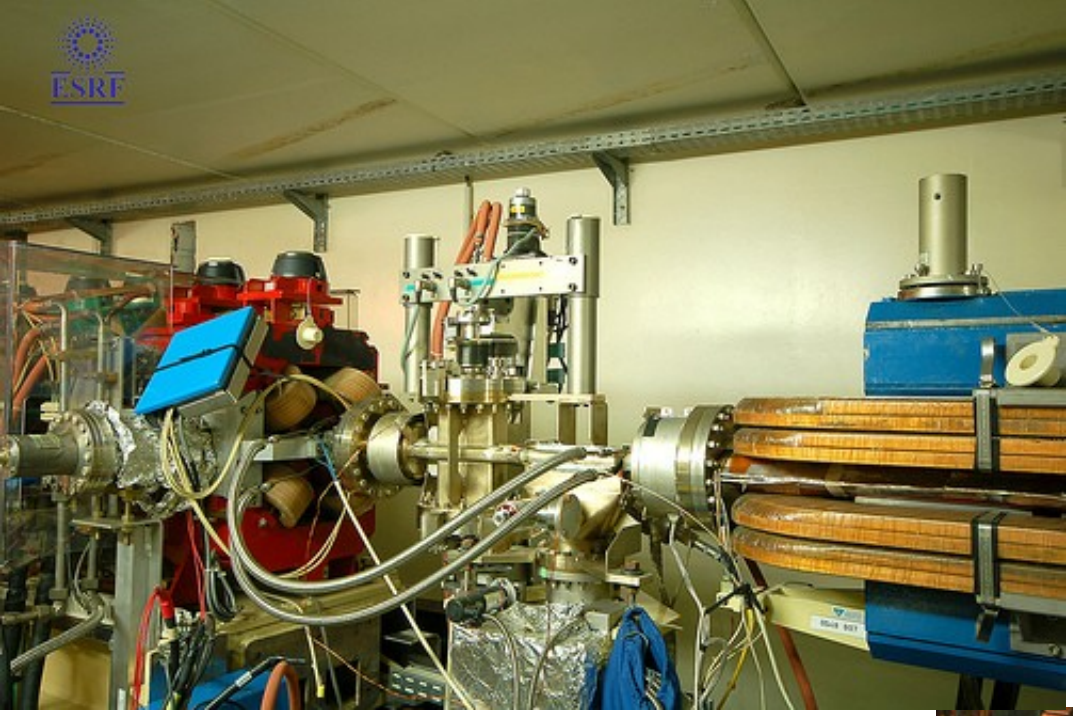
Laurent Nadolski

Frank Schmidt

Masaru Takao

Workshop location

The Ring

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